Analysis of Millimeter Wave Cassegrain Dual-Reflector Cloud Profiling Radar Antenna With Arbitrary Projected Aperture Boundaries

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Abstract

A millimeter wave Cassegrain dual-reflector radar antenna (94.05 GHz) with super-quadric projected aperture boundaries concept that includes sub-reflector blockage effect is evaluated for measurement of the vertical cloud profile structure. This concept has been considered as one approach for the Cloud-SAT instrument design. The design specifications stipulate desired radiation characteristics (gain, sidelobe levels, and beamwidths) and maximum antenna dimension (~1.95 m allowable within the dynamic shroud of the launch vehicle) for nadir looking beam. Particularly challenging in the specifications are the unique very low sidelobe levels desired at far-angle from the peak of the beam, since for a nadir pointed antenna the primary source of noise/clutter is the surface return from previous pulses transmitted and received through the antenna sidelobes. It is imperative that a very accurate and real life antenna model (that includes the sub-reflector and struts blockage effects) is developed in order to be able to obtain an optimum antenna design. And effectively assess and characterize its RF performance, and critically investigate the key parameters that yield far sidelobe levels reduction. Hence, models based on physical optics, PO, and uniform theory of diffraction UTD (that includes sub-reflector blockage effect) for different projected aperture *super-quadric boundaries* and edge tapers are implemented to determine its impact on side-lobe level reduction and gain. The super-quadric representation allows modeling of numerous different projected aperture curves configurations. An aperture field model is then implemented for a millimeter wave pyramidal feed horn for the Cassegrain antenna system. The model is based on the application of the Equivalent Principle. The purpose of this formulation is to determine whether a physically realizable millimeter wave pyramidal feed horn can be designed (to illuminate the sub-reflector) such that its radiation patterns match the desired feed pattern for optimum gain, and low sidelobe levels. A comparison between antenna patterns with and without central blockage effect for -10 dB, and -20 dB edge taper, and super-quadric aperture boundaries are presented. Optimum antenna design for the instrument is given.